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A SYSTEMS ENGINEERING APPROACH TO THE DESIGN OF THE AIR DEFENSE ARTILLERY SIMULATION (ADASIM) ARCHITECTURE

OPERATIONS RESEARCH CENTER OF EXCELLENCE
TECHNICAL REPORT NO: DSE-TR-0432
DTIC REPORT NO: ADA436542

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April 2005

The Operations Research Center is supported by the Assistant Secretary of the Army
(Financial Management & Comptroller)

REPORT DOCUMENTATION PAGE – SF298

Form Approved
OMB No. 0704-0188

1. REPORT DATE *(DD-MM-YYYY)*
June 2004

2. REPORT TYPE
Technical Report

3. DATES COVERED *(From - To)*
01 Oct 03 - 31 May 04

4. TITLE AND SUBTITLE
A Systems Engineering Approach to the Design of the Air Defense Artillery Simulation Architecure (ADASIM)

5a. CONTRACT NUMBER

5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER

6. AUTHOR(S)
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5d. PROJECT NUMBER
DSE-R-0429

5e. TASK NUMBER

5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
Operations Research Center
Dep't of Systems Engineering
US Military Academy
West Point, NY 10996

8. PERFORMING ORGANIZATION REPORT NUMBER
DSE-R-0429

9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)

10. SPONSOR/MONITOR'S ACRONYM(S)

11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION / AVAILABILITY STATEMENT
Distribution A: Approved for public release; distribution is unlimited

13. SUPPLEMENTARY NOTES

14. ABSTRACT
In recent years, the Department of Defense has increased use of modeling and simulation (M&S) to augment and speed the acquisition of new defense systems. This work has included recent interest in using M&S to test new systems at all phases of the design life cycle. A test plan which leverages M&S technologies can drastically cut down on design cost and fielding schedules by identifying shortcoming and performance issues early on, and before making significant investments in time or money. Likewise, M&S drastically improves our ability to conduct integration testing of new and existing systems in large-scale system of systems (SOS) type scenarios where total system testing is infeasible.

However, integration of M&S techniques into current test doctrine requires detailed planning and standardization in order to ensure accurate validation and verification. This has prompted the urgent need for robust and standardized architectures for modeling, simulation, stimulation, instrumentation, data collection, and analyses. As the Army evolves toward a network-centric force, the need for integrated and standard test M&S enabled test environments becomes even more important.

15. SUBJECT TERMS
Air Defense Simulation Architecture

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
					MAJ Jason Wolter
a. REPORT Unclassified	**b. ABSTRACT** Unclassified	**c. THIS PAGE** Unclassified	None	43	**19b. TELEPHONE NUMBER** *(include area code)* 845-938-4888

Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std. Z39.18

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1. INTRODUCTION

"It has been customary to think of operational test and evaluation in terms of physical testing. While operational testing is a very important activity ... it is emphasized that the goal is operational evaluation and that physical testing is only one means of attaining that goal. This is an important point, since it is often argued that operational testing must await production of an adequate number of operationally-configured systems; and, by this time, it is too late to use the information gathered to help decide whether to procure the new system or even influence in any significant way the nature of the system procured."

The Honorable Thomas Christe - Director, DoD Operational Test and Evaluation

1.1 Background

In recent years, the Department of Defense has increased use of modeling and simulation (M&S) to augment and speed the acquisition of new defense systems. This work has included recent interest in using M&S to test new systems at all phases of the design life cycle. A test plan which leverages M&S technologies can drastically cut down on design cost and fielding schedules by identifying shortcoming and performance issues early on, and before making significant investments in time or money. Likewise, M&S drastically improves our ability to conduct integration testing of new and existing systems in large-scale system of systems (SOS) type scenarios where total system testing is infeasible.

However, integration of M&S techniques into current test doctrine requires detailed planning and standardization in order to ensure accurate validation and verification. This has prompted the urgent need for robust and standardized architectures for modeling, simulation, stimulation, instrumentation, data collection, and analyses. As the Army evolves toward a network-centric force, the need for integrated and standard test M&S enabled test environments becomes even more important.

1.2 United States Army Operational Test Command Modeling Effort

Beginning in the summer of 2002, the Army's Operation Test Command (USAOTC) began laying the groundwork for creation of a new generation of "sharing, instrumentation, simulation, and stimulation systems (ISS) [1]" This initiative spawned the creation of the Operational Test Command Analytical Simulation and Instrumentation Suite (OASIS). This family of systems combines the models, simulations, instrumentation, and information technology requirements required by USAOTC to conduct its mission – planning and conducting independent operational testing and experiments in order to provide essential information for the decision making process.

OASIS is a federation of systems focused on the generation of operational test and evaluation data. Each OTC sponsored test may involve a mix of OASIS systems, with each system performing one or more of the following key test and evaluation functions:

- Modeling
- Simulation
- Stimulation
- Data Collection
- Data Transfer
- Data Reduction
- Data Analysis

2. OUR PROBLEM

2.1 Air Defense Artillery Simulation (ADASIM)

One of the systems being developed under the OASIS umbrella is the Air Defense Artillery Simulation (ADASIM). In December 2003, OTC HQ directed that Air Defense Artillery Test Directorate (ADATD) develop requirements for ADASIM that encompass their needs for operational testing of Army systems this fiscal year. OTC also specified that the submission be documented in accordance with the DoD Architectural Framework (DoDAF). The technical director of OTC wants to ensure that the process to generate these requirements is done systematically to ensure that it will standup to budgetary scrutiny.

The following excerpt from an ADATD white paper [2] describes the high level operational need for the ADASIM:

> "The ADASIM will play a critical role in the planning, execution and analysis of future combat system (FCS) equipped units of action (UA). The ADASIM will provide the necessary capabilities for utilizing live, virtual and constructive simulation in a real time distributed environment to provide air defense scenarios, threats, systems, platforms and air space command and control and interoperability. The explicit interdependency of air/ground operations is mentioned nearly continuously in the 'capabilities required' section of the Operational Requirements Document for the Future Combat Systems...This migration of the air defense battlefield operating system from specific ADA systems in a platform-centric organization, to achieve the synergy of a network-centric organization does not relieve Army Test and Evaluation Command (ATEC) from its responsibilities, but requires modification of our approaches to control the operational environment for test and evaluation of this SOS. ADASIM will support test and evaluation at the system level as well. Most conspicuous is the multi-mission radar (MMR). ..ADASIM will be able to emulate this sensor function in the early stages of SOS testing, and stimulate the radar for later testing events. Also, all the FCS platforms will have the requirement, per ORD 3800, to use the alert warning information to resolve a fire control solution on helicopters and UAVs using its integral fire control system and conduct LOS CAFADS engagements within the capabilities of embedded weapons."

2.2 DoDAF

The DoDAF is a standardized framework for building large-scale systems of systems architectures. The framework is mandated by the Information Technology Reform Act and the Office of Management and Budget (OMB) Circular A-130. The purpose of the framework is to standardize the creation of DoD Enterprise Architectures in order to increase enterprise capability, interoperability, and integration. It is a "product-focused" method for standardizing architectures and provides common, pragmatic guidelines for describing architectures. It also provides a mechanism for examining processes and system alternatives in context of mission operations and information requirements [3]. These efforts will ensure that existing and future DoD systems can achieve total interoperability and fully meet the promises heralded by the shift toward network-centric warfare. As one author writes, "Entities that are not interoperable or have limited interoperability will not have access to all available information, will not provide information to entities that may need it, and will be limited in ways in which they can collaborate and work with others. [4]"

The DoDAF provides three interrelated views to represent a system's architecture – system views, operational views, and technical views. The Operational View is a high level description of the tasks and activities, operational nodes or elements, and information exchange requirements between nodes. The System View is a more detailed graphical and textual description of underlying systems within the said architecture, and the interconnections used to satisfy operational needs. The Technical View is an even more detailed window into the minimal set of rules governing the arrangement, interaction, and interdependence of system, parts or elements [3]. DoDAF also provides for an All-View which captures overarching aspects of all three views into a concise set of summary documents.

2.3 Project Deliverables

The ADATD enlisted the help of the Operations Research Center of Excellence (ORCEN) for help creating the initial set of DoDAF documents for ADASIM. Specifically, the ADATD asked the ORCEN to develop the following DoDAF products [5]:

- OV-1 Operational Concept Description
- OV-2 Node Connectivity Diagram
- OV-3 Information Exchange Matrix
- OV-5 Operational Activity
- OV-6C Operational Sequence Diagram
- SV-1 System Interface Description
- SV-7 Service Performance Parameters (for items not covered in OV-3)
- AV-1 Operational and Summary Information
- AV-2 Integrated Dictionary

This technical report is a result of our efforts to complete these tasks. During our initial research into the requirements for constructing the DoDAF documents, we discovered that the DoDAF is largely a product based framework. As one panel described it,

> "The current DoDAF is representation oriented, and does not impose or recommend a process for architecture development. Such a process can be quite sophisticated and can differ across contractors and vendors. Guidance and expertise can prevent the developer from making mistakes others have already made...The is no clear set of criteria to determine what constitutes 'acceptable and good' versus 'unacceptable and poor' for individual view products or the set of products developed [6]"

We offer that much of the aforementioned criticism stems from the simple fact that the DoDAF is a framework. Frameworks are intentionally vague to allow for sufficient flexibility in implementing designs. However, this flexibility must be balanced against the intended standardization goal of DoDAF. We believe that our approach, which employs a systems engineering methodology to develop the DoDAF documents, provides such balance.

3. OUR APPROACH

3.1 The Systems Engineering Management Process (SEMP)

In an effort to inject process into the development of the desired DODAF products, we must first adopt an effective systems engineering methodology. A systems engineering methodology represents a systematic way of decomposing a high-level need into a set of well defined requirements and accompanying designs to satisfy these requirements. Several prominent methodologies abound within the systems engineering discipline. The Design Methods Comparison Project, sponsored by the International Council on Systems Engineering (INCOSE) offers a comprehensive review of contemporary methodologies used in practice [7]. Some of the more well-known methodologies discussed in this project include: the Capability Maturity Model® Integration (CMMI), MIL-STD-499B, EIA/IS Standard 632, and IEEE Standard 1220. Each of these methodologies addresses seven key system engineering activities– State the Problem, Investigate Alternatives, Model, Integrate, Launch, Assess and Re-evaluate (SIMILAR) [7].

We will select and apply a systems engineering methodology known as the Systems Engineering and Management Process (SEMP) in order to address development of the ADASIM architecture. This process, developed at the United States Military Academy, helps engineers systematically design large-scale, complex systems to address problems [8]. The SEMP methodology satisfies the seven fundamental activities required in an effective systems engineering approach as defined by [7], and has been applied to hundreds of civil and military applications. We will first introduce the SEMP in general terms before applying it to the ADASIM design problem. We will then demonstrate its partial application to the ADASIM, and demonstrate how one can use a portion of the process to methodically produce the desired DoDAF products for ADASIM or any other systems engineering process.

The SEMP, shown in Figure 1, is a four phase iterative process involving nine unique steps. A descriptive scenario specifies the current state of a given system or situation. A normative scenario describes the desired state of the system or situation. The difference between these two scenarios is the problem. In the case of ADASIM, the descriptive scenario is the current set of ADATC modeling and simulation tools. The normative scenario is fully deployed ADASIM system that can serve within the OASIS framework.

The engineering process on the inside of the diagram is an iterative process we execute to arrive at the normative scenario. The first phase of the process, the problem definition phase, involves two steps – needs analysis and value system design. The needs analysis step entails understanding, redefining, and formalizing the problem definition. The value system design step involves constructing an upfront value system that fits within the context of the problem definition and can later help ideate and evaluate potential alternatives.

The second phase of the SEMP is the design and analysis phase which is broken down into alternatives generation and modeling and analysis steps. Alternatives generation involves creating potential alternatives to address the needs defined in the needs analysis step. The modeling and analysis step is concerned with identifying the feasibility of alternatives, as well as optimizing and measuring each alternative.

The third phase of the SEMP is the decision making phase which is broken down into the alternative scoring and decision steps. In the alternative scoring step, we use the value system from the problem definition phase to calculate a "total value score" for each alternative. In the decision step, we use these value scores to recommend one alternative to the decision maker. This decision includes a detailed sensitive and cost-value analysis.

The final phase, implementation, involves the three remaining steps of the process – plan of action, execution, and assessment and control. The plan of action represents the project plan detailing how we will implement our winning alterative. Execution involves actually employing hardware, software, and other resources to create the alternative. Assessment and control involves observing and controlling the system over its lifetime.

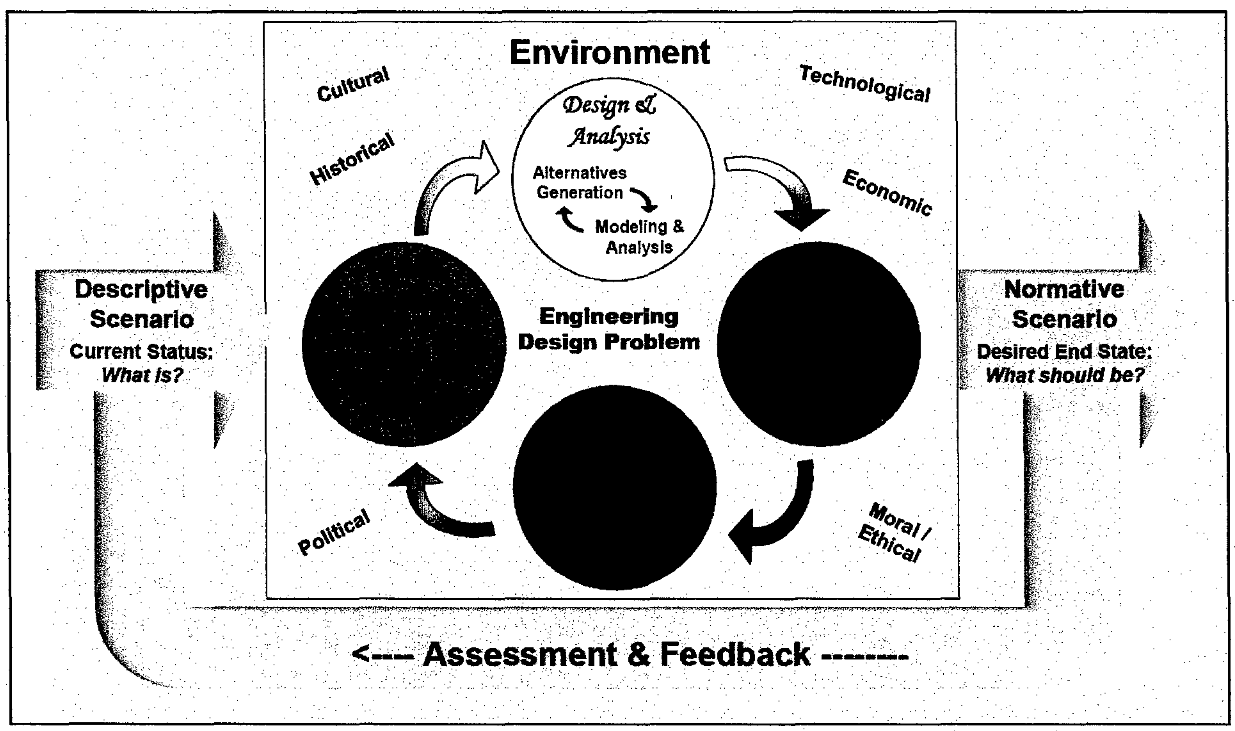

Figure 1 – The Systems Engineering and Management Process

It is important to note the iterative nature of the SEMP and its four major phases. The iteration at each phase represents the continual processing and prototyping that is conducted at each phase until certain conditions are set to commence the next phase. The iterative nature of the SEMP prompts us to re-execute when the descriptive scenario no longer matches the normative scenario.

3.2 SEMP Implementation

We will now turn to implementation of the SEMP process to address the design of the ADASIM. Because the ADASIM is an architecture, and not an actual software or hardware system, we will only execute the first step of this process – Problem Definition. However, it is important to point out that the remaining steps of the SEMP should be applied to an actual implementation of the ADASIM.

While executing the first phase of the SEMP, we will highlight a series of techniques and tools that aid our analysis. In doing so, we will continue to demonstrate how the SEMP can serve as a straight-forward and analytical process for generating DoDAF required documentation. In the interest of brevity, we have moved the DoDAF products to the appendices and will not include them directly in our discussion of the SEMP implementation.

3.2.1 Problem Definition

We begin the application of the SEMP to the ADASIM architecture at the problem definition phase. The problem definition phase helps define the descriptive and normative scenarios, and establishes high level requirements for our design. It is also the genesis of our first DoDAF document – the AV-1 (Overall and Summary Information). As we continue the problem definition step, we will gradually build and expand the AV-1. Appendix A contains the resultant AV-1.

3.2.1.1 Needs Analysis

The problem definition phase starts with the needs analysis step. Needs analysis begins with receipt of the Initial Problem Statement (IPS). This is a rough description of the problem provided by the chief decision maker. In the case of ADASIM, the Air Defense Artillery Test Directorate provided the following initial problem statement [5]:

> *"Apply a systems engineering process focusing on the functional analysis of core Air defense test Directorate (ADATD) mission to produce an architectural framework for Air Defense Artillery simulation that supports OASIS. The purpose of the system is to provide the ability to evaluate Air Defense Artillery systems as part of the Operational Test Command Analytical Simulation and Instrumental Suite (OASIS). Produce architectural design and ancillary perquisite documents in accordance with Department of Defense Architectural Framework (DoDAF)."*

The purpose of the ADASIM, contained in the above Initial problem Statement, is added to the AV-1. Any other high level requirements contained within an initial problem statement should also be added to the AV-1.

3.2.1.1.1 Facts and Assumptions

Our task in the Needs Analysis step is to identify salient facts and assumptions. These facts and assumptions serve to scope and bound our problem. This information helps populate the AV-1, and also provides support for the creation of other DoDAF documents. Additionally, any terminology or other domain knowledge (objects, entities, actors, messages, etc) is added to the AV-2 (Integrated Dictionary).

Facts

- Interoperability. The OASIS M&S federates [i.e. ADASIM] shall be designed to work in conjunction with the DoD Global Information Grid (GIG), the RDECOM Modeling Architecture for Technology and Research Experimentation (MATREX) program, the Future Combat System (FCS) System of Systems Integration Laboratory (SoSIL), other federates, and with the M&S used for battle simulation. This requirement is a time-phased requirement. Initial interoperability shall be achieved through compliance with the Department of Defense (DoD) Joint Technical Architecture (JTA), Department of the Army (DA) Joint Technical Architecture – Army, (JTA-A), DoD Global Information Grid (GIG), Defense Information Infrastructure Common Operating Environment (DII COE) and the High-Level Architecture (HLA) standards. Objective interoperability standards shall be achieved through compliance with the DoD Architecture Framework (DoDAF), Network Centric Enterprise Services (NCES) Standard, the Test and Training Enabling Architecture (TENA), and eventually the Joint Defense Engineering Plant (JDEP) standards. Additionally, OASIS federates shall be capable of communicating over various means, to include wide area networks, local area networks, tactical radios, satellite transmission, and the Defense Research Engineering Network (DREN), as appropriate for each use [9].

- Scalability. The OASIS federates (i.e. ADASIM)shall be capable of performing their functions in test environments from individual systems up to a multi-national coalition Corps and above level exercise. This includes aggregation and de-aggregation capabilities where appropriate. OASIS Components shall be capable of simulating and stimulating operational environments incorporating single and multiple networks, and single to multiple Battlefield Operating Systems (BOS). OASIS federates will be scalable for use in developmental testing and training applications in addition to their primary role of supporting operational testing [9].

- Operational Realism. OASIS (and ADASIM) shall be capable of incorporating operational realism effects in the simulated battlefield, and capturing operational performance data as a result of these effects. These include terrain effects on communications and mobility, weather effects, other communications effects, non-military entities, and the fidelity of entity states. OASIS identifies voids or holes impacting the ability to create operational realism and works to develop models, simulations, and instrumentation necessary to fill those voids. Examples of these voids include a logistics driver, electronic attack (synthetic jamming / computer network operations), non-military models (refugees, vehicle traffic, cell phones, emergency broadcast networks, etc.) and many threat situations to cite a few examples. When equipped with appropriate scenarios, databases, and simulation interfaces, OASIS Components can also provide support to development and integration testing, training, exercises, and military operations planning and analysis [9].

- Standards Compliance. OASIS Components (i.e. ADASIM)shall be developed in accordance with applicable DoD and IEEE standards to facilitate interoperability and compatibility of models and instrumentation for distributed test and evaluation [9].

- Functionality. OASIS Components (i.e. ADASIM)shall provide all functionality necessary to perform the operational tests and evaluations of the FCS and Future Force, including lethality, C4ISR, Battle Command, Maneuver Support, Deployability / Transportability, Tactical Maneuver / Mobility, Survivability, Sustainability, Interoperability, and Training [9].
- Compatibility. OASIS Tools (i.e. ADASIM)shall be compatible with other standards conformant models and instrumentation [9].
- Data Management. OASIS Tools (i.e. ADASIM)shall provide the capability for both centralized and de-centralized data collection, reduction, aggregation, analysis, evaluation, and presentation [9].
- Communications. OASIS Components (i.e. ADASIM)shall support multiple simultaneous communications interfaces such as Wide Area Networks, Local Area Networks, Satellite, and tactical radio over a variety of transmission media for both voice and data [9].
- Information Security. All OASIS Components (i.e. ADASIM)shall be tested and approved to process a variety of information ranging from Unclassified through Top Secret Special Compartmented Intelligence using either the DITSCAP or DODIIS process. The Certification and Accreditation (C&A) requirements for each OASIS component shall be determined by the security classification of the information that component processes. The developer of each component must support and execute this C&A testing. Each federation of OASIS Components must be tested and approved to process classified information at the level specified. OASIS tools shall be managed through a centralized OASIS Configuration Management organization and process [9].
- Distributed. OASIS Components (i.e. ADASIM)shall perform and support distributed modeling and simulation. The operational elements of interoperability, standards compliance, compatability, communications, and information security enable OASIS Components to participate in and utilize distributed modeling and simulation. [9]
- ADASIM will support test and evaluation of the multi-mission radar (MMR). This system is the primary source of detecting air threats manned and unmanned. ADASIM will be able to emulate this sensor function in the early stages of SOS testing, and stimulate the radar for later testing events [2].
- ADASIM will support the testing of FCS systems [2].
- ADASIM will support the testing FCS systems that use alert warning information to resolve a fire control solution on helicopters and UAVs using integral fire control system [2].

- ADASIM will support the testing of FCS systems as they conduct LOS CAFADS engagements within the capabilities of embedded weapons [2].

Assumptions:

- Implementing simulation designs employing the ADASIM architecture will be based on a discrete event simulation paradigm. A discrete event simulation models a system as it evolves over time where system entities change instantaneously at discrete points in time [10]. This assumption is critical in our suggested OV-5 and OV6c documents.

3.2.1.1.2 Stakeholder Analysis

We now turn to the next task in the needs analysis step – Stakeholder Analysis. This important task gathers stakeholder information (contact and background information) and requirements for the ADASIM, and ties these requirements into the overall simulation architecture. These requirements are gathered by identifying the needs, wants, and desires of each stakeholder. This process defines the specific objects, definitions, and functions that populate the following views: AV-1, AV-2, OV-1, O-5, and OV-6a.

The following sections identify the main stakeholders in the ADASIM. These stakeholders are categorized by one or more of five basic stakeholder types – client, analyst, user, decision maker, or sponsor. A client stakeholder represents the primary manager of the desired system. The decision maker, often the same person or agency as the client, represents the agency that will approve the final design. The analyst and user stakeholder types represent specialized and generic users of the resultant design. The sponsor represents the primary financier of the system. Canvassing each of the stakeholder types helps ensure an equal representation of the diverse stakeholders that might be curators in any systems engineering design problem.

Air Defense Artillery Test Directorate (Client/Decision Maker/Sponsor) – ADATD is the primary operational testing organization for air and missile defense weapon systems. Current and recent tests include PATRIOT PAC III, Forward Area Air Defense (FAAD) C3I, and the Sentinel ETRAC radar. This directorate is unique in the span of the horizontal (Army Battle Command System) and vertical (joint links) integration of the command and control integral to these systems. Additionally, operational testing of acquisition programs under the oversight of the highest level require careful consideration of blending live, virtual, and constructive simulation to produce a realistic and certifiable operational scenario. The result of this effort must produce requirements that support efforts for test planning, execution (including integration with real-time instrumentation systems), analysis and control.

OASIS Users/Potential implementing systems (Users). ADASIM users, like any OASIS user, desire a fully interoperable simulation architecture that interfaces with any other OASIS federate. They desire scalability, extensibility, operational realism, standards compliance, functionality, compatibility, data management, effective communications, and information security.

OTC Analysts (Analyst). OTC Analysts desire the same set of requirements as OASIS users. Additionally, the ADASIM must meet all requirements specified for Army Test and Evaluation activities.

3.2.1.1.3 Affinity Diagramming

At this point in our analysis, our analysis has generated a plethora of information facts, assumptions, – stakeholder requirements, domain objects, and domain terminology. In order to better understand and organize this information, we conduct an affinity diagramming process. In this exercise, we place keywords from these disparate ideas, objects, and requirements into an unordered set *U*. We then arrange similar sounding elements of *U* into unidentified subsets u_1, u_2, ... , u_i. Duplicate and meaningless objects are eliminated from these sets. We then analyze each unordered set u_i, and attempt to identify what each member of the subset has in common with its siblings. Once this is established, we assign a meaningful title to each subset u_i. We then document and record each member of each subset u_i and describe the subset headings.

This seemingly trivial exercise serves several key functions. First, it organizes and filters our knowledge and understanding of the problem domain. Second, it identifies critical system components and functions that will populate the System Views (SV) and Operational Views (OV) of our DoDAF documentation. Third, it pairs stakeholder requirements with system functions.

Because of the large volume of needs, wants, desires, functions, and objects identified in earlier phases of the SEMP, we first subdivided our entities into two obvious sub-groups – components and functions. This was largely accomplished by identifying terms and requirements that appear as verbs. When then executed the affinity diagram process on each subgroup, and arrived at the ordered and identified sub-groupings.

3.2.1.1.4 Systems Decomposition

We next turn to conducting a detailed systems decomposition of the desired end system. A complete system decomposition generates a hierarchical, functional, and component view of the proposed ADASIM architecture. This process will lead directly to the development of the SV-1 and SV-2 Views.

Hierarchical Decomposition - Scope and Bound

In order to generate a hierarchical view of the ADASIM, we will arrange the components identified in our affinity diagramming process into super, lateral, and sub systems components of the ADASIM. Super-system components are those components outside the boundary of the ADASIM that encapsulate the functionality of ADASIM. Lateral components represent components outside the boundary that interact with but don't include the ADASIM. Sub-components represent components within the ADASIM boundary (within ADASIM control). It is important to recognize that several components identified in our affinity diagramming might appear as both a lateral and sub component. For example, a friendly force entity such as a missile platform, might be simulated within ADASIM, simulated in a networked simulation in the same federation, or both. Finally, we've only included the main headings of our affinity diagramming process in the interest of clarity.

<u>Super System Components</u>

OASIS

<u>Lateral System Components</u>

Command and Control Objects
External Simulations
Env. Chamber
Live, Virtual, or HITL Sensors
Data Collection Components
Simulation Network
Live, Virtual, or HITL Threat Entities
Neutral Objects of Interest
Interfaces
Data Storage Components
Motion Stimulator
Vibration Table
Friendly Force Units
Friendly Air Objects of Interest

Friendly Ground Objects of Interest
Signal Injection/Projection
Shock Test
Data Analysis Components
Friendly ADA Weapons Systems
Friendly Force Units
Signatures
Testers Node

Sub-System Components

ADASIM Simulation Control
ADASIM Internal Friendly Ground Objects of Interest
ADASIM Internal Friendly Air Objects of Interest
ADASIM Data Management
ADASIM Internal Command and Control Objects
ADASIM Data Collection
ADASIM Data Storage
ADASIM Data Analysis
ADASIM Internal Live, Virtual, or HITL Threat Entities
ADASIM Internal Neutral Objects of Interest
ADASIM Internal Friendly ADA Weapons Systems
ADASIM Internal Friendly Force Units
ADASIM Node
Threats Node
Command and Control Node
External Sensors Node
Support Node
Fires/Sensor Node

In an effort to prime and seed our OV-1 and OV-2 DoDAF documents, we will arrange this hierarchy in a Context Diagram [11]. A context diagram arranges the components from our affinity diagramming process into a logical hierarchy. Figure 2 shows the resultant context diagram.

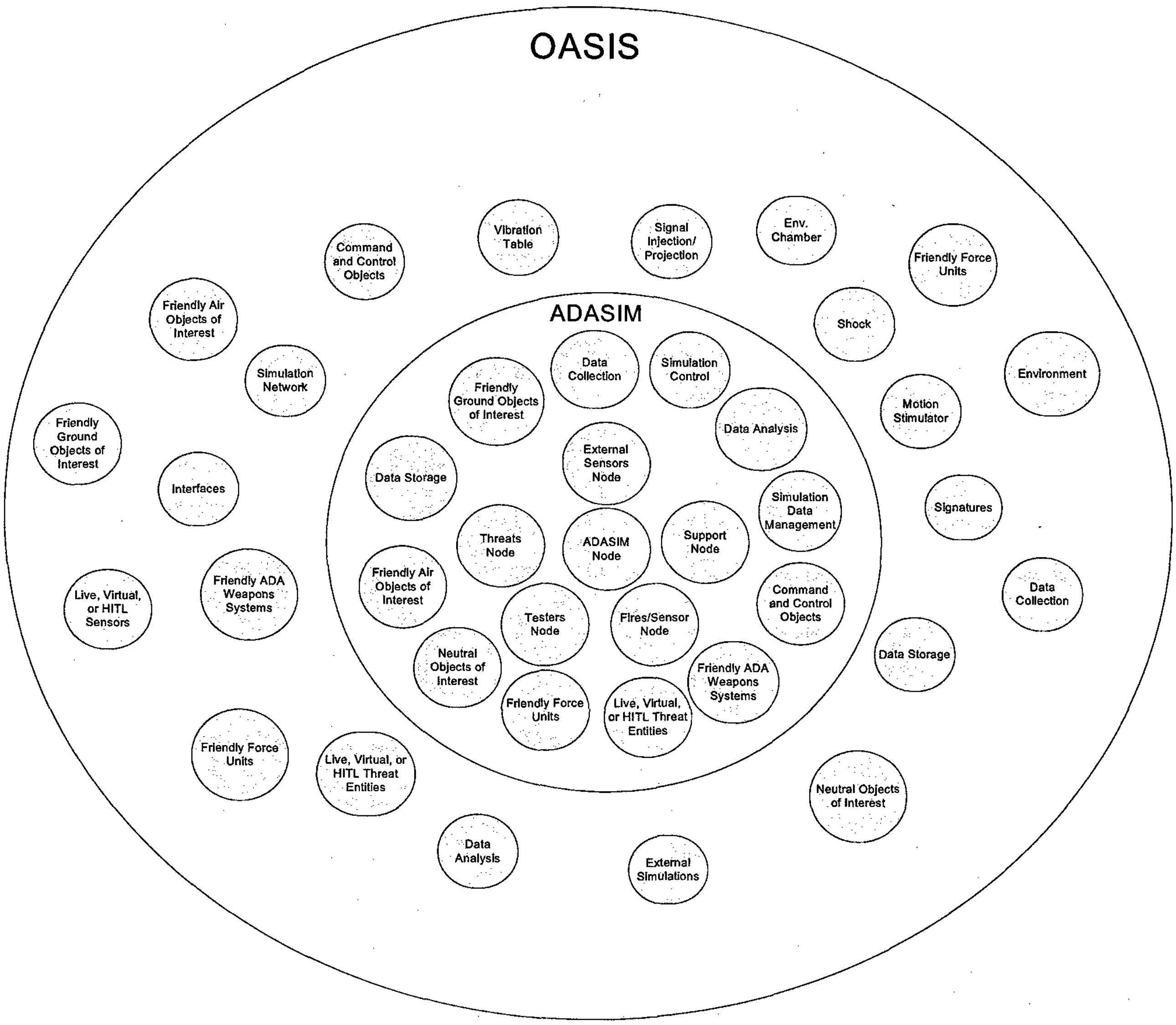

Figure 2 – ADASIM Context Diagram

The hierarchical decomposition described above scopes and bounds the ADASIM. This scoping and bounding is represented in the context diagram above by the circle titled ADASIM. This circle represents the ADASIM's system boundary, or the span of control and responsibility garnered by the ADASIM architecture. Entities outside this boundary will be outside the scope of the ADASIM, but might interact with our architecture.

The hierarchical decomposition also helps prime our OV-1 and OV-2 documents. By following the general structure of the context diagram, we can easily arrange the relevant super, lateral, and sub-system components of the ADASIM architecture into meaningful operational views. These view are listed in Appendix C and D.

3.2.1.1.5 Functional Analysis

After completing our system decomposition, we next turn to the task of completing a functional analysis of the ADASIM architecture. The functional analysis decomposes the system into its key functions, then examines how these functions interact to satisfy the stakeholder needs. These functions and their associated interaction will form the backbone of the SV documents within the DoDAF.

The functional analysis process involves three steps – a functional decomposition, construction of a functional hierarchy, and functional flow analysis.

Functional Decomposition

A functional decomposition of the ADASIM seeks to identify all relevant and salient functions that the desired system should perform. This process is straight forward given the results of the affinity diagramming process. The affinity diagramming process captures the desired functions of the stakeholders, as well as the objects and entities we used earlier in the system decomposition. We simply revisit our affinity diagram product, and extract functional concepts. The important high level functions are shown here:

Adjust Air Defense
Provide Air Defense Coverage
Engage Threat
Control Airspace
Provide Air Defense Command Control
Defense
Sustain Air Defense
Control Simulation

Functional Hierarchy

The next step in the functional analysis of the ADASIM is the construction of a functional hierarchy. The functional hierarchy arranges the functions in our functional decomposition into parent-child relationships. These relationships help use better understand the interaction of various functions within ADASIM. Figure 3 shows the functional hierarchy.

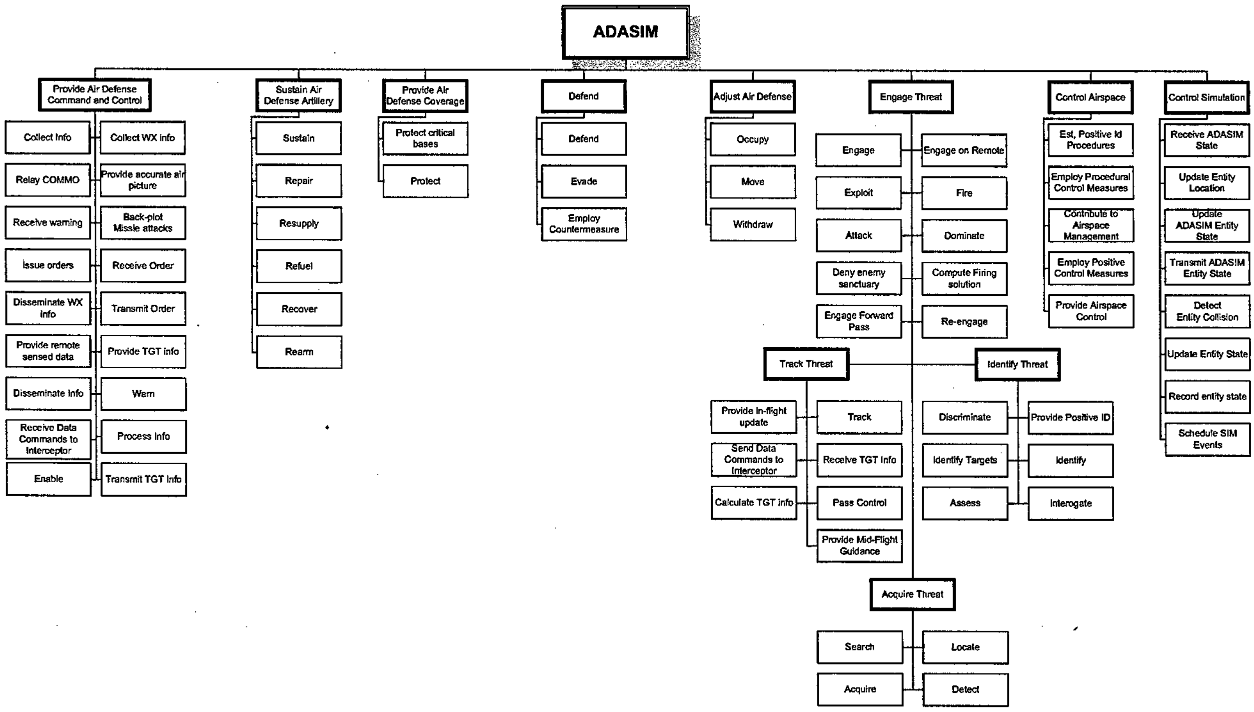

Figure 3 – ADASIM Functional Hierarchy

Functional Flow Analysis

Functional Flow Analysis is the final task within functional analysis, and involves arranging functions into the sequence in which they occur within the system. This arrangement serves the exact purpose of the OV-5 and OV-6a views of the DoDAF. Given the fact that we have already identified our functions in functional decomposition, and arranged them into a functional hierarchy, the task of building our OV-5 and OV-6a documents is much easier.

At this point, we must remember we are defining a simulation architecture. Many of the function titles identified in our functional decomposition suggest the functionality of actual operating weapons systems, not simulation entities or systems under test. Because we are assuming a discrete event simulation, such real-world events as "Engage Threat" will serve as simulation events executed by real or simulated ADASIM or OASIS components. The simulation will control and coordinate these events to support a particular test. In order to reinforce this focus on the simulation, we will rename each of our top level functions in this vein:

Adjust Air Defense ⇒ Execute Air Defense Coverage Adjustment Event

Provide Air Defense Coverage ⇒ Execute Take Active Air Defense Measures Event

Engage Threat ⇒ Execute Engage Target Event

Control Airspace ⇒ Execute Airspace Planning and Coordination Event

Provide Air Defense Command Control ⇒ Execute Air Defense Command and Control Event

Sustain Air Defense ⇒ Execute Sustain Air Defense Measures Event

Control Simulation

Figure 4 shows the top level functional flow for the simulation. The OV-5 and OV-6a views at Appendix E and F provide a detailed view of the complete ADASIM functional flow.

3.3 Future Directions

Because we are designing an architecture that will serve as guidance for other designs, we pause implementation of the SEMP at this point. The remaining steps of the SEMP focus on a specific simulation design, where the ADASIM is a meta-design used to guide the design process of an eventual simulation. Continuing the SEMP, without a particular physical simulation design in mind, would be a premature exercise.

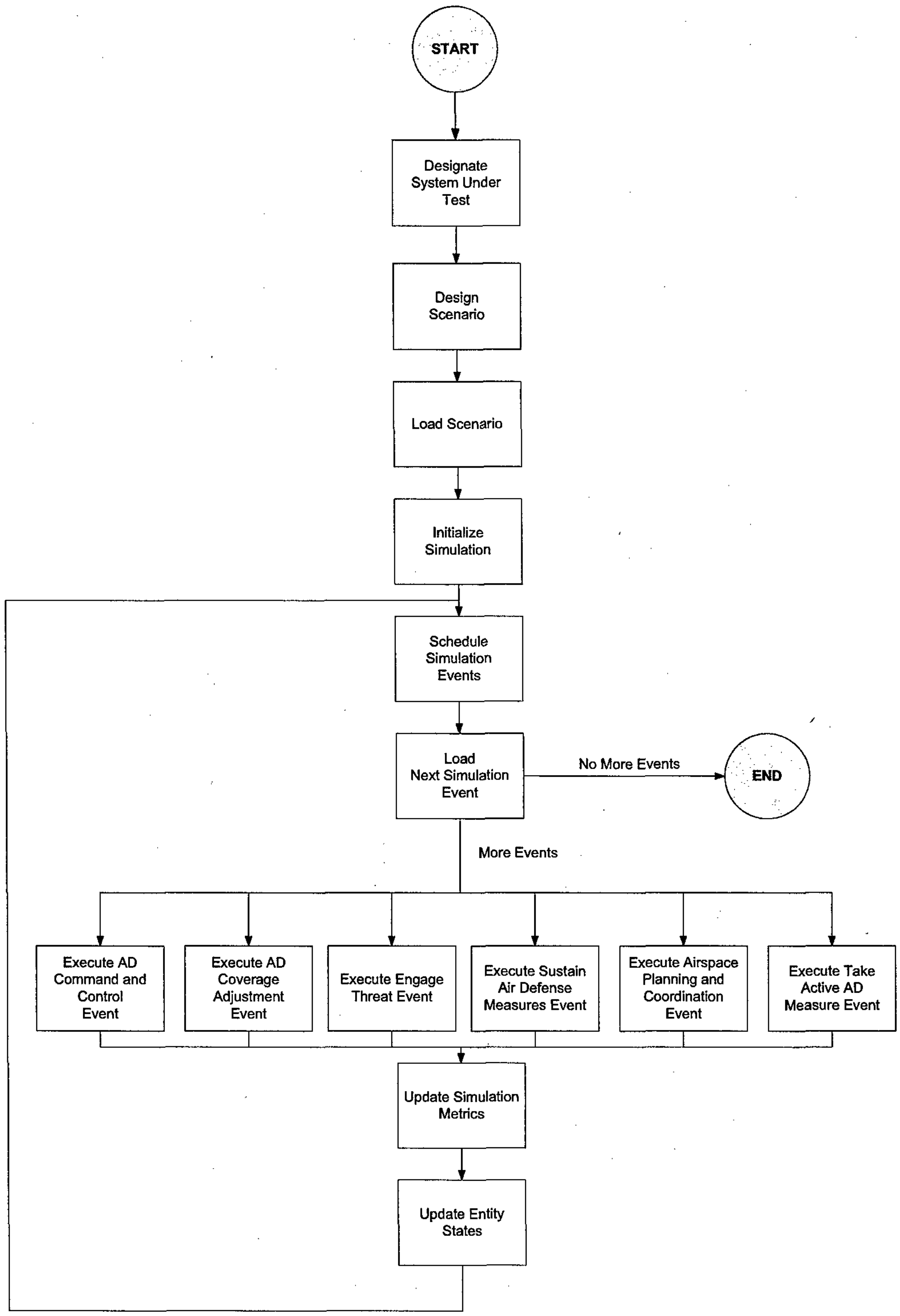

Figure 4 – ADASIM Top-level Functional Flow

However, it is important to highlight that an actual simulation design could initiate the SEMP from this point, and leverage the efforts of the needs analysis. The needs analysis products produced in this documents, with the accompanying ADASIM DoDAF documentation, will help standardize and accelerate the design process. In fact, that is the very purpose of the ADASIM architectural framework.

We recommend that any design efforts to implement an actual ADASIM-based simulation should begin by defining a Revised Problem Statement. The Revised Problem Statement is the final task in the Needs Analysis step of the SEMP. The Revised Problem Statement is used to refine the Initial Problem Statement based on the updated requirements and system information obtained in the preceding steps of Needs Analysis.

4. SUMMARY & CONCLUSION

We have attempted to highlight two main themes in the preceding sections. First, we explained our design methodology used to produce the required ADASIM DoDAF documentation contained in Appendix C. Second, we've offered a theoretical way to inject process into the creation of DoDAF – a framework which, in our opinion, is largely focused on products. This process has demonstrated how systems engineering techniques can help produce required DoDAF documents. The following table summarizes the mappings of several of these techniques to their supported DoDAF counterparts:

SEMP Process	**DoDAF Views Supported**

Initial Problem Statement	OV-1
Stakeholder Analysis	OV-1, OV-2, OV-3
System Decomposition	OV-1, OV-2, SV-1
Functional Analysis	OV-5, OV-6C, SV-6

System Engineering Process – DoDAF Mappings

We conclude with the following suggestion: adhering to a formalized systems engineering methodology is absolutely essential when drafting DoDAF documentation. Focusing solely on the creation of a suite of documents will not necessarily guarantee success. A deliberate systems engineering process, supported by other systems engineering tools and documentation, will greatly enhance the functionality and interoperability of the resultant architecture.

APPENDICES

APPENDIX A: AV-1: Operational Summary Information

APPENDIX B: AV-2: Integrated Dictionary

APPENDIX C: OV-1: ADATC Operational Concept Description

APPENDIX D: OV-2: ADATD Node Connectivity Diagram

APPENDIX E: OV-3: ADATD Information Exchange Matrix

APPENDIX F: OV-5: Operational Activity

APPENDIX G: OV-6C: Operational Sequence Diagram

APPENDIX H: SV-1: System Interface Description

APPENDIX I: SV-6: System/Service Information Exchange Requirements Matrix

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APPENDIX A: Operational and Summary Information (AV-1)

The Operational and Summary Information represents the overall description of the ADASIM project and associated architecture. It is primarily populated from information contained in the original problem statement [5]. Additionally, it contains project details gathered during background research (facts and assumptions) and stakeholder analysis.

ADASIM AV-1

(Note: This is an interactive document, and serves as a gateway to all architecture documents)

IDENTIFICATION	
Name:	Air Defense Artillery (ADA) Modeling and Simulation Architecture
Architects:	Department of Systems Engineering Operations Research Center of Excellence (ORCEN) United States Military Academy, West Point, NY 10996 **POC:** MAJ Steve Henderson steven.henderson@us.army.mil (845) 938-3573
Organization Developing Architecture:	Air Defense Artillery Test Directorate (ADATD) Operational Test Command Fort Bliss, TX **POC:** Mr. Willie Ratcliff Willie.B.Ratcliff@otc.army.mil 915-637-1380
Purpose:	Provide the ability to evaluate Air Defense Artillery systems as part of the Operational Test Command Analytical Simulation and Instrumental Suite (OASIS).

Constraints and Assumptions:	**Constraints** • Interoperability. The OASIS M&S federates [i.e. ADASIM] shall be designed to work in conjunction with the DoD Global Information Grid (GIG), the RDECOM Modeling Architecture for Technology and Research Experimentation (MATREX) program, the Future Combat System (FCS) System of Systems Integration Laboratory (SoSIL), other federates, and with the M&S used for battle simulation. This requirement is a time-phased requirement. Initial interoperability shall be achieved through compliance with the Department of Defense (DoD) Joint Technical Architecture (JTA), Department of the Army (DA) Joint Technical Architecture – Army, (JTA-A), DoD Global Information Grid (GIG), Defense Information Infrastructure Common Operating Environment (DII COE) and the High-Level Architecture (HLA) standards. Objective interoperability standards shall be achieved through compliance with the DoD Architecture Framework (DoDAF), Network Centric Enterprise Services (NCES) Standard, the Test and Training Enabling Architecture (TENA), and eventually the Joint Defense Engineering Plant (JDEP) standards. Additionally, OASIS federates shall be capable of communicating over various means, to include wide area networks, local area networks, tactical radios, satellite transmission, and the Defense Research Engineering Network (DREN), as appropriate for each use [OASIS ICD]. • Scalability. The OASIS federates [i.e. ADASIM] shall be capable of performing their functions in test environments from individual systems up to a multi-national coalition Corps and above level exercise. This includes aggregation and de-aggregation capabilities where appropriate. OASIS Components shall be capable of simulating and stimulating operational environments incorporating single and multiple networks, and single to multiple Battlefield Operating Systems (BOS). OASIS federates will be scalable for use in developmental testing and

	training applications in addition to their primary role of supporting operational testing [OASIS ICD]. • Operational Realism. OASIS (and ADSIM) shall be capable of incorporating operational realism effects in the simulated battlefield, and capturing operational performance data as a result of these effects. These include terrain effects on communications and mobility, weather effects, other communications effects, non-military entities, and the fidelity of entity states. OASIS identifies voids or holes impacting the ability to create operational realism and works to develop models, simulations, and instrumentation necessary to fill those voids. Examples of these voids include a logistics driver, electronic attack (synthetic jamming / computer network operations), non-military models (refugees, vehicle traffic, cell phones, emergency broadcast networks, etc.) and many threat situations to cite a few examples. When equipped with appropriate scenarios, databases, and simulation interfaces, OASIS Components can also provide support to development and integration testing, training, exercises, and military operations planning and analysis [OASIS ICD]. • Standards Compliance. OASIS Components [i.e. ADASIM] shall be developed in accordance with applicable DoD and IEEE standards to facilitate interoperability and compatibility of models and instrumentation for distributed test and evaluation [OASIS ICD]. • Functionality. OASIS Components [i.e. ADASIM] shall provide all functionality necessary to perform the operational tests and evaluations of the FCS and Future Force, including lethality, C4ISR, Battle Command, Maneuver Support, Deployability / Transportability, Tactical Maneuver / Mobility, Survivability, Sustainability, Interoperability, and Training [OASIS ICD]. • Compatibility. OASIS Tools [i.e. ADASIM] shall be compatible with other standards conformant models and instrumentation [OASIS ICD]. • Data Management. OASIS Tools [i.e. ADASIM]

	shall provide the capability for both centralized and de-centralized data collection, reduction, aggregation, analysis, evaluation, and presentation [OASIS ICD]. • Communications. OASIS Components [i.e. ADASIM] shall support multiple simultaneous communications interfaces such as Wide Area Networks, Local Area Networks, Satellite, and tactical radio over a variety of transmission media for both voice and data [OASIS ICD]. • Information Security. All OASIS Components [i.e. ADASIM] shall be tested and approved to process a variety of information ranging from Unclassified through Top Secret Special Compartmented Intelligence using either the DITSCAP or DODIIS process. The Certification and Accreditation (C&A) requirements for each OASIS component shall be determined by the security classification of the information that component processes. The developer of each component must support and execute this C&A testing. Each federation of OASIS Components must be tested and approved to process classified information at the level specified. OASIS tools shall be managed through a centralized OASIS Configuration Management organization and process [OASIS ICD]. • Distributed. OASIS Components [i.e. ADASIM] shall perform and support distributed modeling and simulation. The operational elements of interoperability, standards compliance, compatability, communications, and information security enable OASIS Components to participate in and utilize distributed modeling and simulation. [OASIS ICD] • ADASIM will support test and evaluation of the multi-mission radar (MMR). This system is the primary source of detecting air threats manned and unmanned. ADASIM will be able to emulate this sensor function in the early stages of SOS testing, and stimulate the radar for later testing events.

	• ADASIM will support the testing of FCS systems [MAJ Matty Email] • ADASIM will support the testing FCS systems that use alert warning information to resolve a fire control solution on helicopters and UAVs using integral fire control system. [ADASIM White Paper] • ADASIM will support the testing of FCS systems as they conduct LOS CAFADS engagements within the capabilities of embedded weapons. [ADASIM White Paper] **Assumptions:** • Implementing simulation designs employing the ADASIM architecture will be based on a discrete event simulation paradigm. A discrete event simulation models a system as it evolves over time where system entities change instantaneously at discrete points in time [See Law/Kelton, 6]. This assumption is critical in our suggested OV-5 and OV6c documents.
ARCHITECTURE IDENTIFICATION	
Name:	ADASIM
Date Completed:	15 MAR 2005
SCOPE	
Views and Products Used:	AV-1 - Operational and Summary Information OV-1 – Operational Concept Description OV-2 – Node Connectivity Diagram OV-3 – Information Exchange Matrix

	OV-5 – Operational Activity Diagram OV-6c – Operational Sequence Diagram SV-1 - System Interface Description SV-6 – System/Service Information Exchange Req Matrix AV-2 – Integrated Dictionary Technical Report
PURPOSE AND VIEWPOINT	
Questions to be Answered by Analysis of Architecture:	• What are the operational requirements for the systems under this architecture? • What are the deficiencies in the current capabilities? • What are the requirements for a new system to meet the deficiencies? • Which approach best meets needs regarding ADA products developed/acquired? • What is the test planning process for the ADA systems developed under this architecture? • Which Architecture products are used for testing and when? • How will interoperability be evaluated using the architecture? • How do ADA products measure up for interoperability? • What are the interoperability gaps that need to be fixed? • How do existing products fit into the new architecture?

	• What is the test architecture for a given test, using the ADA architecture? • What are the impacts of changes to the System Under Test (SUT) on the architecture and the M&S products?
From Whose Viewpoint is the Architecture Described:	An analyst who has little to no background in Air Defense Systems
CONTEXT	
Mission	Air Defense
Doctrine, Goals, and Vision	Air Defense
Expected Threats	All known
Geographical Area Addressed	Non-specific
Tools and File Formats	
Microsoft PowerPoint : OV1, OV2, SV1 Microsoft Excel : AV2, OV3, SV6 Microsoft Vision 2002 : OV5, OV6c HTML: AV1	
Findings	
Analysis Results:	See ADASIM Technical Report
Recommendations:	See ADASIM Technical Report

APPENDIX B: ADASIM Integrated Dictionary (AV-2)

The ADASIM Integrated Dictionary contains definitions of all relevant terms and abbreviations contained in any of the ADASIM DoDAF documents. These terms were collected throughout the entire design process.

Term	Definition	Where Appears
ABT Threat	Air-breathing threats.	OV-1
Acknowledge	A message from a receiver to a sender telling the sender that the receiver received and understands the last transmission.	OV6C : Take Active AD Measures OV6C : Sustain Air Defense Operations OV6C : Plan and Coordinate Air Defense OV6C : Adjust AD Coverage OV6C : Provide Air Defense Command and Control
Active Sensing	A special mode of radar when the radar is searching for targets.	OV6C : Engage Threat
Active Tracking	A special mode of radar when the radar has acquired a target and continually updates the target location, speed, attitude, etc.	OV6C : Engage Threat OV6C : Take Active AD Measures
ADASIM	Air Defense Artillery Simulation Architecture.	ALL
ADASIM Node	The node in the simulation architecture responsible for control of the simulation.	OV6C : Engage Threat OV6C : Take Active AD Measures OV6C : Sustain Air Defense Operations OV6C : Adjust AD Coverage OV6C : Provide Air Defense Command and Control
Air Defense Warning	A degree of air raid probability according to the following code. The term air defense division/sector referred to herein may include forces and units afloat and/or deployed to forward areas, as applicable. The initial declaration of air defense emergency will automatically establish a condition of air defense warning other than white for purposes of security control of air traffic. See FMs 44-63 and 44-100.	
Airborne C4 Node	An airborne command, control, communications, and computers system	OV-1
Airborne Sensor	Any sensor deployed in the air	OV-1
Airborne Weapon	Any weapons system that is primary deployed in the air.	OV-1
Airspace Control Measure	Rules, mechanisms, and directions governed by joint doctrine and defined by the airspace control plan which control the use of airspace of specified dimensions. (See also high-density airspace control zone (HIDACZ), low-level transit route (LLTR), minimum-risk route (MRR), and standard use Army aircraft flight route (SAAFR).) See FM 100-103.	OV-5
AMD	Air Missile Defense	SV-1
AMDTF System	A system that is part of the Air Missile Defense Task Force.	SV-1
Analysis Tool	A tool used to analyze the results of the simulation	SV-1
Assessing	The process of determining the effectiveness of an	OV-2

	engagement.	
Assign Effector	The process of designating a particular weapons system for an engagement.	OV-2
Attack Alarm	An urgent or priority Air Defense Warning.	OV6C : Take Active AD Measures
Attack Guidance	A higher headquarters' guidance on the conduct, timing, and target priorities of an attack operation.	OV-2
Avenger	A pre-FCS ere US Army air defense system.	SV-1
Broadcast	The act of sending a message to more than one station at the same time.	SV-1
C4	Command, control, communications and computers.	OV-1
C4 Node	A command, control, communications and computers node.	OV-1
Clock	The simulation clock that is used to synchronize all simulation events.	SV-1
CLOE	Common Logistics operating Element.	SV-1
CM Threat	An enemy cruise missile threat.	OV-1
Collaborative Engagement	The process in which two or more entities combine information and assets to engage a target.	
Collaborative Tracking	The process in which two or more entities combine information and assets to track a target.	
Commanders Critical Information Requirements	Information required by the commander that directly affects his decisions and dictates the successful execution of operational or tactical operations. CCIR normally result in the generation of three types of information requirements: priority intelligence requirements, essential elements of friendly information, and friendly force information requirements.	
Common Operating Picture	A single identical display of relevant information shared by more than one command. A common operational picture facilitates collaborative planning and assists all echelons to achieve situational awareness.	SV-1
Common Services	Those simulation services that are common to all nodes - terrain databases, weather effects, etc.	SV-1
Communicate Component	The part of a simulation node responsible for communicating with other nodes.	SV-1
COP/CROP	Common Operational Picture/Common Relevant Operational Picture	OV-2
Cue First Mission	A simulation message instructing the simulation to load the first mission	OV6C : Sustain Air Defense Operations
Cue Simulation	A simulation message instructing the simulation to load initiate the simulation.	OV6C : Provide Air Defense Command and Control
Data Collection Process	A process within the simulation dedicated to collecting raw data for later analysis.	SV-1
Early Warning Plan	The plan detailing the actions for early notification of the launch or approach of unknown weapons or weapon carriers	OV-5
Elevated Sensor	A sensor that is permanently airborne (via blimp, airship, etc).	OV-1
Enemy State	Current information about a threat entity's state - location, attitude, disposition, strength, or any other attribute describing the threat entity at the current time.	SV-1
Engagement	The process of one entity firing on another with the goal of disabling or destroying it.	OV6C : Engage Threat OV6C : Take Active AD Measures
Event Directives	Actions that each node will conduct for a particular simulation event.	SV-1
Event List	A list of all current and future events within the simulation.	SV-1

External Sensor Node	The node in the simulation architecture responsible for simulating all sensors that are external to Army systems - satellites, off-shore radar, AWACs, etc.	OV6C : Engage Threat OV6C : Take Active AD Measures OV6C : Sustain Air Defense Operations OV6C : Adjust AD Coverage OV6C : Provide Air Defense Command and Control
External Tracking Info	Information about a target that originates from an external system.	OV6C : Engage Threat OV6C : Take Active AD Measures
FCS	The Future Combat Systems (FCS) is a joint (across all the military services) networked (connected via advanced communications) systems of systems (one large system made up of 18 individual systems plus the network and Soldier- often referred to as 18 plus one plus one).	
FCS/FIFV (MC)	The future infantry fighting vehicle (FIFV) for the future combat system (FCS).	OV-1
Fire Command	A specific sequence of information given by a control authority (for example, a vehicle commander or fire direction center) that causes a crew to begin performing a sequence of actions and provides detailed direction to choose the ammunition type, aim the weapon, and engage the target. Each element given by the controller requires a response from a crew member to ensure correct aiming and engagement. After the initial fire command, subsequent fire commands using the same sequence of information can be used to adjust the point of impact to ensure the desired target effect. See FMs 6-series, 7-90, 7-91, 17-12, and 23-1.	OV6C : Engage Threat OV6C : Take Active AD Measures
Fires Sensor Node	The node in the simulation architecture responsible for simulating those native systems that fire and sense - e.g. A Patriot Missile Battery	OV6C : Engage Threat OV6C : Take Active AD Measures OV6C : Sustain Air Defense Operations OV6C : Adjust AD Coverage OV6C : Provide Air Defense Command and Control
Fragmentary Order (FRAGO)	An abbreviated form of an operation order, usually issued on a day-to-day basis, which eliminates the need for restating information contained in a basic operation order. It may be issued in sections.	OV6C : Adjust AD Coverage
FRAGO	See Fragmentary Order.	
FW	Fixed-wing.	SV-1
General Orders	General instructions from a higher headquarters to subordinates. Include Fire commands, Weapons Control Status, Rules of Engagement, Target Priorities, Commanders Critical Information Requirements, Attack Alarms, Air Defense Warnings.	OV6C : Provide Air Defense Command and Control
GUI Data	Simulation data pertaining to the functionality of the Graphical User Interface (GUI) .	OV-2
Headquarters Node	The node in the simulation architecture responsible for simulating all command and control activities.	OV6C : Engage Threat OV6C : Take Active AD Measures OV6C : Sustain Air Defense Operations OV6C : Adjust AD Coverage OV6C : Provide Air Defense Command and Control
Higher HQ FRAGO	A Fragmentary Order originating from higher headquarters.	OV6C : Adjust AD Coverage
HQ	Headquarters.	OV-5
HSOC	Home station operating station.	SV-1
IFF	Identify Friend or Foe.	OV-5
IFF Procedures	Specific instructions on how to identify friend or foe (given an unknown target).	OV-5

Initialize	A simulation message instructing entities to perform all pre-simulation tasks.	OV6C : Engage Threat OV6C : Take Active AD Measures OV6C : Sustain Air Defense Operations OV6C : Plan and Coordinate Air Defense OV6C : Adjust AD Coverage OV6C : Provide Air Defense Command and Control
JDN	Joint Data Network.	SV-1
JLENS	Joint Land Attack Cruise Missile Defense Elevated Netted Sensor System .	SV-1
Joint Data Network	A common DoD network used by all services.	SV-1
Landline	Commercial telephone lines or military equivalent.	SV-1
Linebacker	A pre-FCS ere US Army air defense system.	SV-1
Logistics Info	Information pertaining to the logistical readiness and state of a system or node.	SV-1
LOS/BLOS WPN	The Line-of-Sight / Beyond Line-of-Sight (LOS/BLOS) weapon is a FCS combat vehicle with 105-120mm cannon with LOS/BLOS capability. It will be developed in the FCS 120mm LOS/BLOS ATD. Also included is a Self Protection Weapon.	
M3P System	Multi-Mission Mobile Processor.	SV-1
MEADS BTRY	A Medium Extended Air Defense System battery of air defense artillery.	OV-1
Messages	Simulation messages that synchronize and coordinate activity between multiple simulation nodes.	OV-2
METT-TC	Mission, Enemy, Time, Troops, Time, Civilians	OV-5
MRM	Medium Range Missile.	SV-1
MULE	Multifunction Utility/Logistics Equipment Vehicle (robotic vehicle intended to support dismounted troops) .	SV-1
Network	A common simulation network linking two or more disparate simulations or nodes.	SV-1
Next Mission	A simulation message instructing participating entities to load their next scripted mission.	OV6C : Plan and Coordinate Air Defense
NLOS WPN	A non-line of sight weapon system. The NLOS weapon system is an FCS combat vehicle with 120-155mm cannon with NLOS capability. This system incorporates technologies that include CARGO rounds and smart sub munitions, and Fire and Forget Seeker technology. Also included is a Self Protection Weapon.	
Node metrics	Measurable values that reflect the performance metrics of the node and its subordinate objects. See Performance Metrics.	OV6C : Engage ThreatOV6C : Take Active AD MeasuresOV6C : Sustain Air Defense OperationsOV6C : Plan and Coordinate Air DefenseOV6C : Adjust AD CoverageOV6C : Provide Air Defense Command and ControlSV-1
Operations Order	A directive issued by the commander to subordinate commanders for the purpose of affecting the coordinated execution of an operation	OV6C : Plan and Coordinate Air Defense OV6C : Provide Air Defense Command and Control
Orders	General instructions from a higher headquarters to subordinates. Include Fire commands, Weapons Control Status, Rules of Engagement, Target Priorities, Commanders Critical Information Requirements, Attack Alarms, Air Defense Warnings.	SV-1

Output	General output from the simulation to the user. i.e. - metrics, feedback, error reports, status, etc.	SV-1
Post-Simulation Analysis	The process of analyzing the simulation results to determine the effectiveness of the system under test.	SV-1
Prepare for New Mission	A message from a higher headquarters to a subordinate unit instructing them to prepare for a new mission (See Warning Order)	OV6C : Plan and Coordinate Air Defense
Ready for Next Event	A simulation message indicating the simulation is ready to process its next scheduled event.	OV6C : Engage Threat OV6C : Take Active AD Measures OV6C : Sustain Air Defense Operations OV6C : Plan and Coordinate Air Defense OV6C : Adjust AD Coverage OV6C : Provide Air Defense Command and Control
Report Generation	A simulation process (usually done during post-simulation analysis) where custom reports are created to help analyze the results of the simulation.	SV-1
RF	Radar frequency.	SV-1
Robotic Mortar FCS/AREMS	A largely automated mortar weapon system in the Future Combat Systems suite of vehicles.	OV-1
Robotic Mule	The Multifunction Utility/Logistics Equipment Vehicle (MULE) is an unmanned platform that provides transport of equipment and/or supplies in support of dismounted maneuver	OV-1
Rotary Threat	An enemy helicopter.	OV-1
Rules of Engagement	Directives issued by competent military authority which delineate the circumstances and limitations under which US forces will initiate and/or continue combat engagement with other forces encountered. See FM 100-20.	OV-6c, OV-5
RW	Rotary-wing.	SV-1
Scenario	A set of terrain, weather, friendly forces, enemy forces, and missions used to define a particular instance of a simulation.	SV-1
Scenario Execution	The process of running a scenario from start to finish.	SV-1
Scenario Generation	The process of creating a scenario.	SV-1
Scenario Playback	The process of watching a scenario again, after it has already been simulated.	SV-1
Sense Component	The part of a simulation node responsible for sensing external objects and events.	SV-1
Simulation Metrics	Simulation data pertaining to the inner workings of the simulation.	SV-1
SLAMRAAM	The Surfaced-Launched Advanced Medium Range Air-to-Air Missile (SLAMRAAM) is the Army's future short-range air defense weapon	OV-1
Space-based Sensor	A sensor that is located on a space-based platform.	OV-1
Space-based system	A system that is located on a space-based platform.	SV-1
Start Monitoring SUT	A cue to start monitoring the System Under Test (SUT)	OV6C : Engage ThreatOV6C : Take Active AD MeasuresOV6C : Sustain Air Defense OperationsOV6C : Plan and Coordinate Air DefenseOV6C : Adjust AD CoverageOV6C : Provide Air Defense Command and Control
State data	See State Information.	SV-1
State Info	Current information about an entity's state - location, attitude, disposition, strength, or any other attribute describing the threat entity at the current time.	SV-1

Support Node	The node in the simulation architecture responsible for simulating all support or logistics activities.	OV6C : Engage Threat OV6C : Take Active AD Measures OV6C : Sustain Air Defense Operations OV6C : Plan and Coordinate Air Defense OV6C : Adjust AD Coverage OV6C : Provide Air Defense Command and Control
Sustainment Activity	Any process that provides personnel, logistic, and other support activity.	OV6C : Sustain Air Defense Operations
Sustainment Demand	Personnel, logistic, and other support requirements.	OV6C : Sustain Air Defense Operations
Sustainment Plan	The plan detailing the provision of personnel, logistic, and other support required to maintain and prolong operations or combat.	OV-5, OV6C : Sustain Air Defense Operations
Synchronization	The process of synchronizing simulation events across multiple simulation nodes.	OV-2, OV-5
System Under Test	The Air Defense System being tested by the simulation.	OV-5
Target Priorities	A list of which targets should be fired on before other targets.	
Targeting	Information required by weapons systems to compute a firing solution for and engage a target.	SV-1
TBM	Tactical ballistic missile.	SV-1
Test Data	Simulation data pertaining to the design and conduct of the test.	OV-2
Test Execution	The actual execution of the test that uses the ADASIM.	OV-2
Test Planning	The design of and preparation for the test that will use the ADASIM .	OV-2
Testers Node	The node in the simulation architecture responsible for interfacing with the test managers.	OV6C : Engage Threat OV6C : Take Active AD Measures OV6C : Sustain Air Defense Operations OV6C : Plan and Coordinate Air Defense OV6C : Adjust AD Coverage OV6C : Provide Air Defense Command and Control
THAAD BTRY	A Theater High-Altitude Area Defense [THAAD] battery.	OV-1
Thinker Component	The part of a simulation node responsible for processing information and making decisions.	SV-1
Threat Signature	A measurable & detectable emission from any enemy object - i.e. sound, light, radar signature, etc.	OV6C : Engage Threat OV6C : Take Active AD Measures
Threat State	See Threat State Information.	OV6C : Engage Threat OV6C : Take Active AD Measures
Threat State Information	Current information about a threat entity's state - location, attitude, disposition, strength, or any other attribute describing the threat entity at the current time.	OV6C : Engage Threat OV6C : Take Active AD Measures
Threats Node	The node in the simulation architecture responsible for simulating enemy or threat activity.	OV6C : Engage Threat OV6C : Take Active AD Measures OV6C : Sustain Air Defense Operations OV6C : Plan and Coordinate Air Defense OV6C : Adjust AD Coverage OV6C : Provide Air Defense Command and Control
Tracking	A special mode of radar when the radar has acquired a target and continually updates the target location, speed, attitude, etc.	SV-1
Tracking & Collaborative Engagement Command	A command facilitating a collaborative engagement or collaborative tracking.	OV6C : Engage Threat
UAV	Unmanned aerial vehicle.	OV-1
UAV Threat	An enemy unmanned-aerial vehicle.	OV-1

Updated Simulation Metrics	Measurable values that reflect the relative performance of the simulation or simulation objects. For example, a simulated probability of kill.	OV6C : Engage Threat OV6C : Take Active AD Measures OV6C : Sustain Air Defense Operations OV6C : Plan and Coordinate Air Defense OV6C : Adjust AD Coverage OV6C : Provide Air Defense Command and Control
Updated State Information	Current information about a simulation entity's state - location, attitude, disposition, strength, or any other attribute describing that entity at the current time.	OV6C : Take Active AD Measures OV6C : Sustain Air Defense OperationsOV6C : Plan and Coordinate Air Defense OV6C : Adjust AD Coverage OV6C : Provide Air Defense Command and Control
User Input	General input (commands, responses) from the user to the simulation.	SV-1
VTOL FCS/VAAV	A vertical take-of unmanned aerial vehicle.	OV-1
Warning Order	A planning directive that describes the situation, allocates forces and resources, establishes command relationships, provides other initial planning guidance, and initiates subordinate unit mission planning.	OV6C : Plan and Coordinate Air Defense OV5
Weapons Control Status	The degree of fire control imposed upon Army units having assigned, attached, or organic air defense weapons. Weapons control status terms are: weapons free, weapons tight, and weapons hold. See FMs 44-63 and 44-100.	OV-5, OV-6c

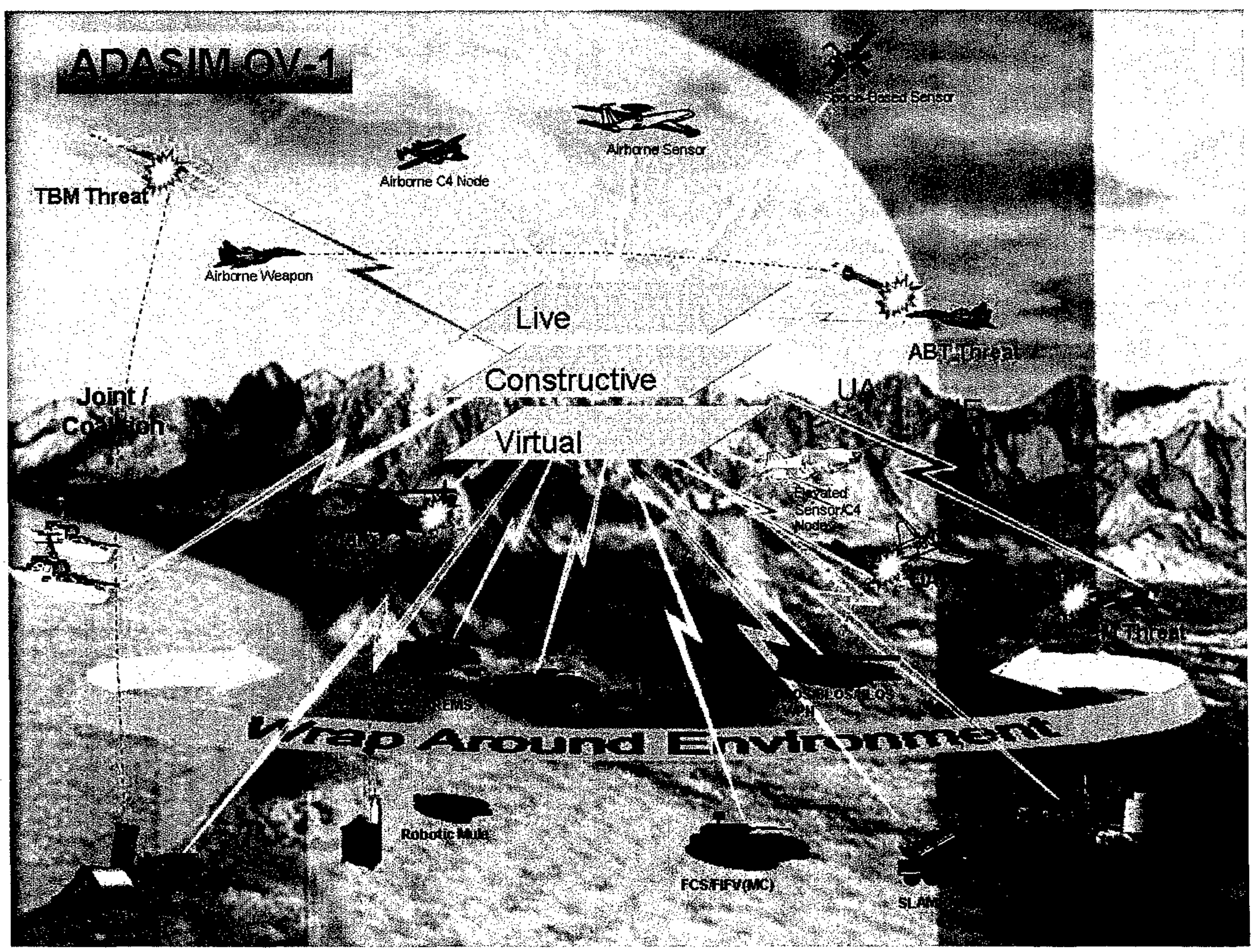
APPENDIX C: ADASIM Operational Concept Diagram (OV-1)

The ADASIM OV-1 (Figure C-3) represents the top operational view of the ADASIM simulation architecture. This diagram sets the context and scope of the ADASIM architecture, and follows from the system decomposition process discussed in earlier sections. The boundary of the ADASIM architecture is represented by the set of all major battlefield systems that might appear in a particular Air Defense simulation. These objects form the components and sub-components of our ADASIM architecture, and will appear as entities in any implementing simulation. These entities might represent a particular system under test (e.g. SLAM/RAAM) or potential targets (e.g. UAV Threat).

We enumerated the components in this view during an affinity diagramming exercise. This affinity diagramming process, a structured brain-storming exercise, pulled entities from three primary areas. First, we examined current Air Defense doctrine, and extracted the major systems currently appearing on the modern battlefield. Second, because the ADASIM will largely support the fielding of new systems, we also researched Future Combat System literature to identify important future battlefield systems. Third, we leveraged the experience of military personnel with experience in the Air Defense domain.

The diagram also features visual depictions of particular simulation-specific features of the ADASIM architecture. This helps define the scope of functionality that ADASIM-based simulations will provide. In the center of the diagram, we show three parallel planes. These planes represent the various states of existence of participating systems. A system participating in an ADASIM-based simulation might be a live physical system (hardware-in-the-loop), constructive (a partially implemented prototype), or completely virtual. Any ADASIM compliant simulation will handle any of the three types.

The "Wrap Around Environment" circle represents a common simulation environment that cuts across all participating entities in the system. This environment is made up of common simulation services that are shared by two or more entities. These include common terrain databases, data management functions, event handling, and network management functions.



APPENDIX D : ADASIM Node Connectivity Diagram (OV-2)

The OV-2 is made up of seven functional nodes. Each node represents a particular functional theme exhibited by components that participate in an ADASIM-based simulation. Each of these nodes encapsulates the common tasks, modeling aspects, and algorithms that are needed to implement each particular function.

The ADASIM Node is the central node in the architecture. This node models all simulation-specific tasks. These tasks include, but are not limited to the following: simulation timing, event list management, message passing, interface with simulation/test managers, and interface with external simulation federations, conflict resolution, and integration of common services.

The Testers Node represents the tasks and functionality required to interface with the ADASIM Test Managers. This includes simulation input, simulation output, GUI generation, simulation scenario modeling, and management of performance measures and other simulation assessment mechanisms.

The Fires/Sensor Node encapsulates the simulation of those battlefield systems that have organic weapons and sensors. For example, the Army's Avenger weapons system has both onboard weapons and sensors.

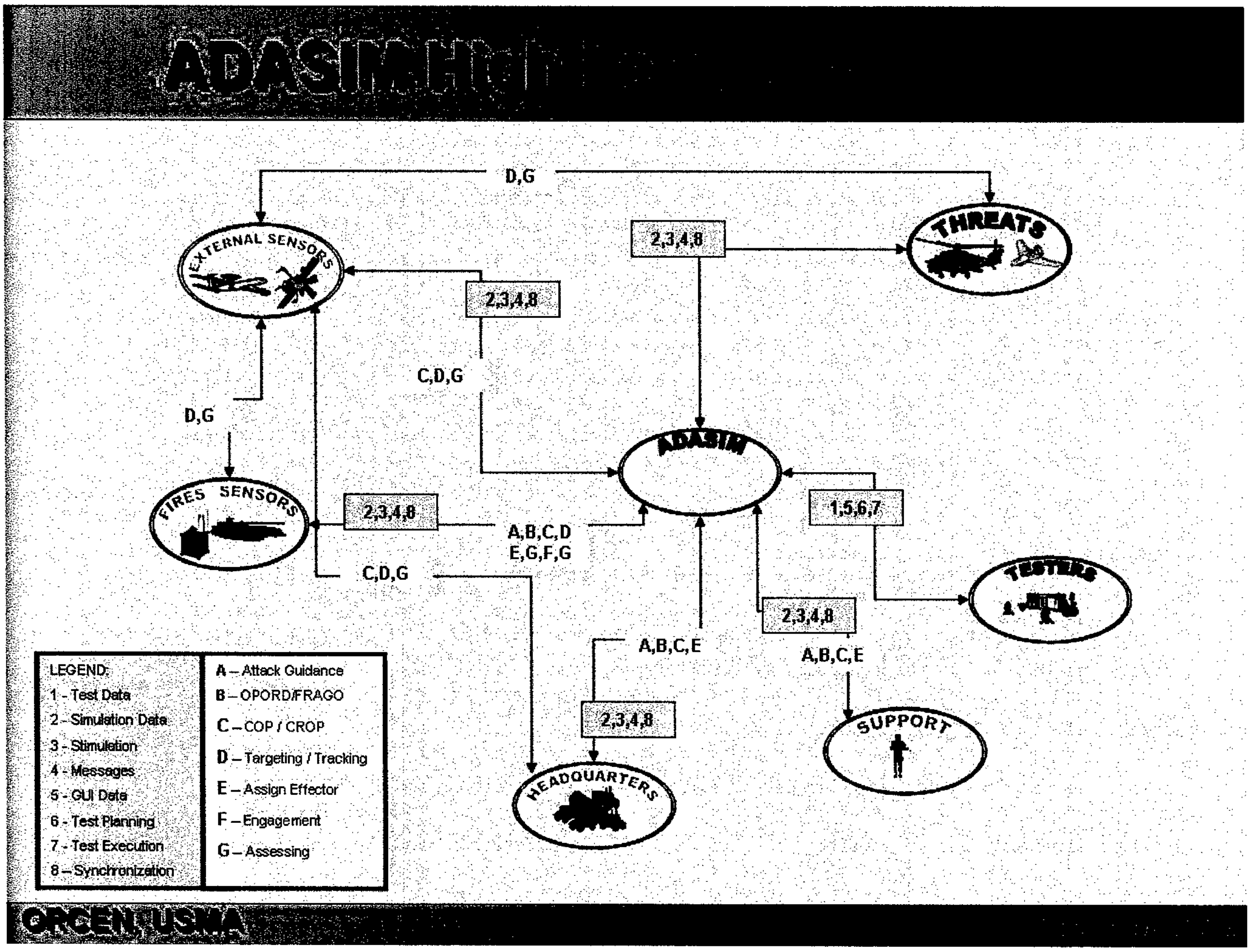
The External Sensors Node represents the simulation of any external sensor system.

The Threats Node is responsible for representing enemy simulation entities. Grouping threat entities into a common node allows the architecture to better model characteristics common to all threat objects. For example, enemy doctrine, language, or a common enemy battleplan.

The Support Node represents the entities in the simulation that provide logistics support to other entities.

The Headquarters Node manages all Command and Control entities in the simulation. Particular functionality includes simulation of communications networks, decision making, and common-operating picture representation.

The diagram also details high-level information exchange between the nodes. These information exchange requirements are summarized in the Information Exchange Matrix (OV-3 at Appendix E).


ADASIM
D,G
EXTERNAL SENSORS
THREATS
2,3,4,8
2,3,4,8
C,D,G
D,G
ADASIM
FIRES SENSORS
2,3,4,8
A,B,C,D
E,G,F,G
1,5,6,7
C,D,G
TESTERS
2,3,4,8
A,B,C,E
A,B,C,E
2,3,4,8
SUPPORT
HEADQUARTERS
LEGEND:
1 - Test Data
2 - Simulation Data
3 - Stimulation
4 - Messages
5 - GUI Data
6 - Test Planning
7 - Test Execution
8 – Synchronization
A – Attack Guidance
B – OPORD/FRAGO
C – COP / CROP
D – Targeting / Tracking
E – Assign Effector
F – Engagement
G – Assessing
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APPENDIX E : ADASIM Information Exchange Matrix (OV-3)

The information exchange matrix describes the critical information that flows between each node (See OV-2 at Appendix D). The information was derived during our fact gathering process, stakeholder analysis, and functional analysis. Additionally, as we constructed the OV-6c (Operational Sequence Diagram) we captured critical information flows that were required to achieve the desired level of functionality.

This information is expounded in the SV-6 (Appendix I). The SV-6 shows a more refined view of the specific types of messages that make up the broad categories list in the OV-3.

Information Requirement	Consumer Node	Consumer Element	Consumer Process	Producer Node	Producer Element	Producer Process	Communication Characteristic	Speed of Service	Frequency	Perishability
Air Attack Alarm	Fires/Sensor Node	Shooter/Sensor	Execute Air Attack Alarm	Headquarters Node	Headquarters Element	Issue Air Attack Alarm	Digital or voice	Rapid	Low	Low
Air Attack Alarm	External Sensor	External Sensor System	Execute Air Attack Alarm	Headquarters Node	Headquarters Element	Issue Air Attack Alarm	Digital or voice	Rapid	Low	Low
Air Attack Alarm	Support Node	Support Node	Execute Air Attack Alarm	Headquarters Node	Headquarters Element	Issue Air Attack Alarm	Digital or voice	Rapid	Low	Low
Airspace Control Measures	Fires/Sensor Node	Shooter/Sensor	Execute Airspace Control Measures	Headquarters Node	Headquarters Element	Issue Airspace Control Measures	Digital or voice	Rapid	Low	Low
Airspace Control Measures	External Sensor	External Sensor System	Execute Airspace Control Measures	Headquarters Node	Headquarters Element	Issue Airspace Control Measures	Digital or voice	Rapid	Low	Low
Early Warning Plan	Fires/Sensor Node	Shooter/Sensor	Execute Early Warning Plan	Headquarters Node	Headquarters Element	Issue Early Warning Plan	Digital or voice	Rapid	Low	Low
Early Warning Plan	External Sensor	External Sensor System	Execute Early Warning Plan	Headquarters Node	Headquarters Element	Issue Early Warning Plan	Digital or voice	Rapid	Low	Low
Early Warning Plan	Support Node	Support Node	Execute Early Warning Plan	Headquarters Node	Headquarters Element	Issue Early Warning Plan	Digital or voice	Rapid	Low	Low
Friendly Force State	Headquarters Node	Headquarters Element	Supervise Plan	External Sensor Node	External Sensor System	(All Processes)	Digital or voice	Rapid	Medium	Medium
Friendly Force State	Headquarters Node	Headquarters Element	Supervise Plan	Fires/Shooter Node	Shooter/Sensor	(All Processes)	Digital or voice	Rapid	Medium	Medium
Friendly Force State	Headquarters Node	Headquarters Element	Supervise Plan	Support Node	Support Element	(All Processes)	Digital or voice	Rapid	Medium	Medium
Friendly Force State	Headquarters Node	Headquarters Element	Assess Friendly Forces	External Sensor Node	External Sensor System	(All Processes)	Digital or voice	Rapid	Medium	Medium
Friendly Force State	Headquarters Node	Headquarters Element	Assess Friendly Forces	Fires/Shooter Node	Shooter/Sensor	(All Processes)	Digital or voice	Rapid	Medium	Medium
Friendly Force State	Headquarters Node	Headquarters Element	Assess Friendly Forces	Support Node	Support Element	(All Processes)	Digital or voice	Rapid	Medium	Medium
Friendly Force State	Headquarters Node	Headquarters Element	Report Friendly Force State	Headquarters Node	Higher Headquarters Element	Report Friendly Force State	Digital or voice	Rapid	Medium	Medium
IFF Procedures	Fires/Sensor Node	Shooter/Sensor	Execute IFF Procedures	Headquarters Node	Headquarters Element	Issue IFF Procedures	Digital or voice	Rapid	Low	Low
IFF Procedures	External Sensor	External Sensor System	Execute IFF Procedures	Headquarters Node	Headquarters Element	Issue IFF Procedures	Digital or voice	Rapid	Low	Low
IFF Procedures	Support Node	Support Node	Execute IFF Procedures	Headquarters Node	Headquarters Element	Issue IFF Procedures	Digital or voice	Rapid	Low	Low
Node Metrics	ADASIM Node	ADASIM Implementation	Compute Metrics	Headquarters Node	Headquarters Element	(All Processes)	Digital	Rapid	Medium	Low

Node Metrics	ADASIM Node	ADASIM Implementation	Compute Metrics	Headquarters Node	Headquarters Element	(All Processes)	Digital	Rapid	Medium	Low
Node Metrics	ADASIM Node	ADASIM Implementation	Compute Metrics	Threats Node	Headquarters Element	(All Processes)	Digital	Rapid	Medium	Low
Node Metrics	ADASIM Node	ADASIM Implementation	Compute Metrics	External Sensor Node	Headquarters Element	(All Processes)	Digital	Rapid	Medium	Low
Node Metrics	ADASIM Node	ADASIM Implementation	Compute Metrics	Fires/Shooter Node	Headquarters Element	(All Processes)	Digital	Rapid	Medium	Low
Node Metrics	ADASIM Node	ADASIM Implementation	Compute Metrics	Support Node	Support Element	(All Processes)	Digital	Rapid	Medium	Low
Node Metrics	Headquarters Node	Headquarters Element	(All Processes)	ADASIM Node	ADASIM Implementation	Update Metrics	Digital	Rapid	Medium	Low
Node Metrics	External Sensor	External Sensor System	(All Processes)	ADASIM Node	ADASIM Implementation	Update Metrics	Digital	Rapid	Medium	Low
Node Metrics	Fires/Sensor Node	Shooter/Sensor	(All Processes)	ADASIM Node	ADASIM Implementation	Update Metrics	Digital	Rapid	Medium	Low
Node Metrics	Support Node	Support Node System	(All Processes)	ADASIM Node	ADASIM Implementation	Update Metrics	Digital	Rapid	Medium	Low
Node Metrics	Threats Node	Threat System	(All Processes)	ADASIM Node	ADASIM Implementation	Update Metrics	Digital	Rapid	Medium	Low
Operations Order	Fires/Sensor Node	Shooter/Sensor	Execute AD Plan	Headquarters Node	Headquarters Element	Issue Operations Order	Digital or voice	Rapid	Low	Low
Operations Order	External Sensor	External Sensor System	Execute AD Plan	Headquarters Node	Headquarters Element	Issue Operations Order	Digital or voice	Rapid	Low	Low
Operations Order	Support Node	Support Node	Execute AD Plan	Headquarters Node	Headquarters Element	Issue Operations Order	Digital or voice	Rapid	Low	Low
Rules of Engagement	Fires/Sensor Node	Shooter/Sensor	Execute Rules of Engagement	Headquarters Node	Headquarters Element	Issue Rules of Engagement	Digital or voice	Rapid	Low	Low
Rules of Engagement	External Sensor	External Sensor System	Execute Rules of Engagement	Headquarters Node	Headquarters Element	Issue Rules of Engagement	Digital or voice	Rapid	Low	Low
Rules of Engagement	Support Node	Support Node	Execute Rules of Engagement	Headquarters Node	Headquarters Element	Issue Rules of Engagement	Digital or voice	Rapid	Low	Low
Simulation Metrics	Testers Node	Analyst	Evaluate Simulation Results	ADASIM Node	ADASIM Implementation	Compute Metrics	Digital	Rapid	Medium	Low
Sustainment Plan	Support Node	Support Node System	Execute Support Plan	Headquarters Node	Headquarters Element	Publish Sustainment Plan	Digital or voice	Rapid	Low	Low
System Under Test Metrics	Testers Node	Analyst	Evaluate Simulation Results	ADASIM Node	ADASIM Implementation	Compute Metrics	Digital	Rapid	Medium	Low
Target Priorities	Fires/Sensor Node	Shooter/Sensor	Execute Target Priorities	Headquarters Node	Headquarters Element	Issue Target Priorities	Digital or voice	Rapid	Low	Low
Target Priorities	External Sensor	External Sensor System	Execute Target Priorities	Headquarters Node	Headquarters Element	Issue Target Priorities	Digital or voice	Rapid	Low	Low
Target Priorities	Support Node	Support Node	Execute Target Priorities	Headquarters Node	Headquarters Element	Issue Target Priorities	Digital or voice	Rapid	Low	Low

Threat Signature	External Sensor	External Sensor System	Search for Threat	Threat Node	Threat System	Execute Enemy Mission	Radar, IR, visual, acoustic	Instantaneous	High	High
Threat Signature	Fires/Sensor Node	Shooter/Sensor	Search for Threat	Threat Node	Threat System	Execute Enemy Mission	Radar, IR, visual, acoustic	Instantaneous	High	High
Threat Signature	External Sensor	External Sensor System	Acquire Threat	Threat Node	Threat System	Execute Enemy Mission	Radar, IR, visual, acoustic	Instantaneous	High	High
Threat Signature	Fires/Sensor Node	Shooter/Sensor	Acquire Threat	Threat Node	Threat System	Execute Enemy Mission	Radar, IR, visual, acoustic	Instantaneous	High	High
Threat Signature	External Sensor	External Sensor System	Track Threat	Threat Node	Threat System	Execute Enemy Mission	Radar, IR, visual, acoustic	Instantaneous	High	High
Threat Signature	Fires/Sensor Node	Shooter/Sensor	Track Threat	Threat Node	Threat System	Execute Enemy Mission	Radar, IR, visual, acoustic	Instantaneous	High	High
Threat State	Headquarters Node	Headquarters Element	Assess Threat	External Sensor Node	External Sensor System	Track Threat	Digital or voice	Instantaneous	High	High
Threat State	Headquarters Node	Shooter/Sensor	Assess Threat	Fires/Shooter Node	Shooter/Sensor	Track Threat	Digital or voice	Instantaneous	High	High
Threat State	Headquarters Node	Headquarters Element	Notify Higher Headquarters	Headquarters Node	Higher Echelon Headquarters Element	Assess Threat	Digital or voice	Instantaneous	High	High
Warning Order	Fires/Sensor Node	Shooter/Sensor	Begin Movement	Headquarters Node	Headquarters Element	Issue Warning Order	Digital or voice	Rapid	Low	Low
Warning Order	External Sensor	External Sensor System	Begin Movement	Headquarters Node	Headquarters Element	Issue Warning Order	Digital or voice	Rapid	Low	Low
Warning Order	Support Node	Support Node	Begin Movement	Headquarters Node	Headquarters Element	Issue Warning Order	Digital or voice	Rapid	Low	Low
Weapons Control Status	Fires/Sensor Node	Shooter/Sensor	Execute Weapons Control Status	Headquarters Node	Headquarters Element	Issue Weapons Control Status	Digital or voice	Rapid	Low	Low
Weapons Control Status	External Sensor	External Sensor System	Execute Weapons Control Status	Headquarters Node	Headquarters Element	Issue Weapons Control Status	Digital or voice	Rapid	Low	Low
Weapons Control Status	Support Node	Support Node	Execute Weapons Control Status	Headquarters Node	Headquarters Element	Issue Weapons Control Status	Digital or voice	Rapid	Low	Low

Appendix F : Operational Activity Diagram (OV-5)

The OV-5 is divided into seven sub-documents:

Simulation Control

Engage Threat Event

Plan and Coordinate Air Defense Event

Take Active Air Defense Event

Sustain Air Defense Event

Provide Air Defense Command and Control Event

Adjust Air Defense Coverage Event

The Simulation Control OV-5 shows the top level functionality of ADASIM. The diagram begins with ADASIM performing common simulation initialize functions – i.e. designation of a system under test, scenario design, etc. The simulation then proceeds to build an initial master simulation event list. This event list is populated based on initial events contained in the simulation scenario.

The simulation then proceeds with the following loop, until no more simulation events are left on the simulation event list. The simulation first executes the next simulation event, which is one of six top-level Air Defense mission events encountered by ADASIM: Engage Threat Event, Plan and Coordinate Air Defense Event, Take Active Air Defense Event, Sustain Air Defense Event, Provide Air Defense Command and Control Event, or Adjust Air Defense Coverage Event. Each of these events is further refined in its own individual OV-5, and contains smaller simulation events (e.g. Track Threat, Receive OPORD, etc).

The smaller simulation events were extracted from current ADA doctrinal publications (ARTEP MTPs). For each ADA Mission event (Engage Threat Event, Plan and Coordinate Air Defense Event, Take Active Air Defense Event, etc), we looked at the doctrinal steps that are required for satisfactory completion of that top-level mission event. These steps represent the low-level functions in each OV-5 diagram.

Once completing the entire Air Defense mission event, the simulation returns to the Simulation Control OV-5, records any metrics, generates any new events resulting from the last one. The simulation loops back and grabs the next simulation event (if applicable) or computes/reports final metrics and ends the simulation.

The actual OV-5 is omitted from this document due to its size. The actual OV-5 can be obtained through the Operations Research Center of Excellence or via the Internet at http://www.orcen.usma.edu/adasim/index.asp

Appendix G: OV-6C : Operational Sequence Diagram

The ADASIM Operational Sequence diagram contains six sub-documents: Simulation Control, Engage Threat Event, Plan and Coordinate Air Defense Event, Take Active Air Defense Event, Sustain Air Defense Event, Provide Air Defense Command and Control Event, Adjust Air Defense Coverage Event. Each of these corresponds to an associated OV-5 sub-document.

Each OV-6C shows the low level sequence of events for each of the six major Air Defense mission events. The diagrams also show low-level information exchanges between modes that occur during each low-level function. These low-level messages are numbered, and are described in the SV-6 (System/Service Information Exchange Requirements Matrix). This documents is provided at Appendix I.

The interaction between nodes represents the node-node communication that corresponds to each of the sub-functions listed in the OV-5. As mentioned in Appendix F, these function represent the necessary doctrinal steps required for successful completion of the top-level ADA mission event (Engage Threat Even, Plan and Coordinate Air Defense Event, Take Active Air Defense Event, etc).

The actual OV-6 is omitted from this document due to its size. The actual OV-6 can be obtained through the Operations Research Center of Excellence or via the Internet at http://www.orcen.usma.edu/adasim/index.asp

Appendix H: SV-1 (System Interface Description)

The SV-1 describes the general design and functionality of the six principal ADASIM nodes. This includes a description of interfaces each node maintains with other nodes well as common ADASIM services.

The general functionality provided by each node is broken into four primary components – a communications component, a platform component, a thinker component, and a sensor component. These components represent core functionality common to all nodes. The communication component represents common communications functions of the node and includes interfaces and Application Program Interfaces (APIs) for real or virtual communication via network (LAN/Intranet), landline, Joint Data Network, and many other protocols. The platform component contains common interfaces and APIs for movement, launching, signature generation, etc. The thinker component represents interface and APIs for any intelligent processes that are required by the node. This includes real or simulated human interaction/behavior as well as intelligent agents within the node. The sense component represents common interfaces and APIs for sensor functionality.

The diagram also shows interfaces for common simulation services provided by ADASIM, or pass-through service provided from other OASIS federates through ADASIM. These common services include: simulation setup, maps, terrain, weather, friendly/threat unit management, post-simulation analysis, data collection, and real networking.

The actual SV-1 is omitted from this document due to its size. The actual SV-1 can be obtained through the Operations Research Center of Excellence or via the Internet at http://www.orcen.usma.edu/adasim/index.asp.

Appendix I : SV-6 (System Information Exchange Requirements Matrix).

The System/Service Information Exchange Requirements Matrix details the low level messages that occur between nodes. Each of these corresponds to one or more node-node interactions listed in the OV-6c. (Appendix G) Additionally, each message corresponds to a high-level information exchange requirement listed in the OV-3 (Appendix E).

The actual SV-6 is omitted from this document due to its size. The actual SV-6 can be obtained through the Operations Research Center of Excellence or via the Internet at http://www.orcen.usma.edu/adasim/index.asp

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